CEMENT

AND

CEMENT MANUFACTURE

A MONTHLY JOURNAL FOR ALL INTERESTED IN THE MANUFACTURE, CHEMISTRY & TESTING OF CEMENT

VOL. I. No. 4.

LEADING CONTENTS

PAGE

Imported Cement 87

Transporting Pump for Cement 89

A 40,000-Ton a Year Plant 93

Notes from Abroad 96

The Maintenance of Cement Plant. *By Alfred B. Searle* . . . 97

Book Review 99

Enlarged Calcination Zones in Rotary Kilns. *By Geoffrey Martin, D.Sc., Ph.D., F.I.C., F.C.S.* 101

The Portland Cement Industry To-day. *By A. C. Davis, M.I.Mech.E., M.Inst.C.E.I., F.C.S.* 105

Recent Improvements in Portland Cement 112

DECEMBER, 1928

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ISSUED AS A SUPPLEMENT TO "CONCRETE & CONSTRUCTIONAL ENGINEERING"
BY CONCRETE PUBLICATIONS LTD., 20 DARTMOUTH STREET, LONDON, S.W.1

Price 1s. 6d. Monthly. Annual Subscription 18s.

VOL. I. NO. 4. DECEMBER, 1928.

Imported Cement.

THE reproduction below is of a cartoon issued by the United States National Builders' Supply Association, in which is set out the amount lost to American labour through the importation into that country of cement from abroad.

The total value of cement imported into the United States in 1927 was 2,956,451 dollars. The last month for which figures are available is April, 1928, when the total value was 324,371 dollars. Of this total cement to the value of 267,303 dollars was imported from Belgium, 44,860 dollars from Denmark, 6,022 dollars from the United Kingdom, 3,297 dollars from France, and 2,889 dollars from elsewhere. It was recently stated by the general manager of the North American Cement Corporation that the importation of Belgian cement into the area supplied by his Company had caused a reduction of 72,723 barrels in its output last year. The British cement industry is thus not alone in suffering from foreign competition, the strength of which is shown by the fact that Belgium can sell in the United States in spite of the cost of freight across the 3,000 odd miles that separate the two countries. Post-war conditions have had curious effects. In some countries, Great Britain included, the cost of living and wages have increased enormously, with a consequent increase in the cost of production of cement as well as other commodities. In other countries wages are low, and the low production costs allow the manufacturers in those countries to undersell in the countries where high wages rule. Trade unions in this country are not likely to agree to lower wages in cement factories, and the country as a whole does not wish to see wages depressed ; while on the Continent

Use of Foreign Cement costs me my job!
Use American Cement and keep me at my job!
FOREIGN CEMENT
AMERICAN CEMENT
ELEVEN MILLION BARRELS OF FOREIGN CEMENT—
Sold in American Market Since 1921
—Cost American Wage Earners:
Lost!
American Workers 1,905,956 Working Days
American Payrolls 11,253,963 Dollars

all the efforts of socialism do not seem to be able to increase wages or shorten hours, and neither does there seem to be any insistent public demand for better conditions.

While some people will always buy in the cheapest market, even if the cheap product is so inferior as to be really a bad bargain, much can be done by taking a broader view and realising that by paying a little more for the home-produced material not only is better value obtained but the lessening of unemployment will also rebound to the benefit of all. We are glad to note that some of the local authorities are realising that any small saving on foreign cement is dearly bought by the relief out of public funds paid to the men now unemployed, and who might be self-supporting citizens busily engaged making British materials for British use. But many important public bodies continue to use foreign goods which, bearing in mind the enormous cost of unemployment, could be more economically made at home (witness the foreign tiles and bricks on London County Council and other housing estates). Local authorities too often take the view that unemployment in Kent or the Midlands is no concern of London or Brighton, forgetting that every worker in the country is paying a direct levy in the shape of an Unemployment Insurance contribution that could probably be halved if national unemployment were halved; forgetting that seaside resorts suffer when so many of the population have no funds for an annual holiday; forgetting national matters in the all-important need for reducing the local rates a few pence in view of the next election.

It is not sufficient to deplore the unemployment caused by the importation of foreign goods; the glib phrases of the politician are of less than no value; it is the practical policy of insisting on British goods that will reduce unemployment, taxation and high rates at one and the same time.

It should be noted that the participation by Great Britain in the cement imports of the United States is not obtained by price-cutting, but on superior quality, and consists almost entirely of rapid-hardening Portland cement.

Correspondence.

SIR,—With regard to some remarks in your leading article in the November issue of "Cement & Cement Manufacture," under the heading of "Silica and Quality," I might mention that the Aargau Portland Cement Works, at Holderbank-Wildegg, in Switzerland, has made a rapid-hardening Portland cement for some years, and about twelve years ago this cement was used for making French gun emplacements during the war.

The quality of this cement does not appear to be inferior to that of rapid hardening cements made in this country, but it is not ground so finely. Apart from the extra care necessary throughout manufacture when producing rapid-hardening cement, extreme care is exercised at this works with regard to the proportioning of the raw materials. Not only is the proportion of calcium carbonate carefully controlled, but a certain definite ratio is maintained between the quantity of ferric oxide on the one hand and silica and alumina on the other.

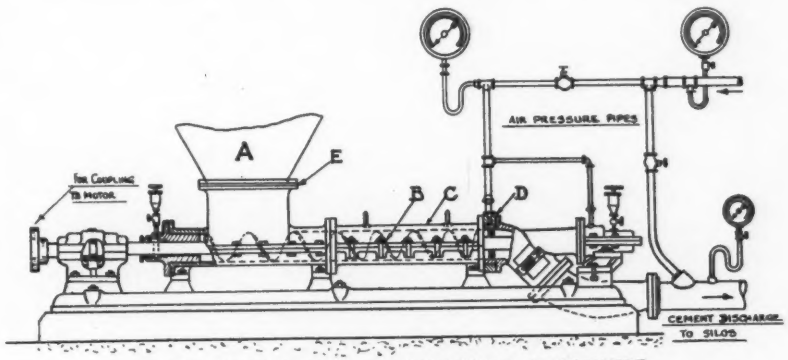
The Company claims that in this way it avoids such extremely fine grinding as is necessary in this country, and obtains equal results. This is an important point owing to the expense and difficulty experienced when grinding down to 1·5 per cent. or 2 per cent. residue on the 180-sieve. After all, the proof of the pudding is in the eating, and certainly this Swiss company appear to obtain rapid-hardening results with less effort.

HENRY POOLEY, B.Sc., A.M.Inst.C.E.
London.

Transporting Pump for Cement.

In the old days of small units, small outputs, and small flat-bottomed warehouses, no difficulties or inconveniences were experienced in conveying and elevating finished cement. With the introduction of single mills producing 18 or 20 tons per hour, and the installation of groups of these mills with a total output of 100 or 120 tons per hour of finely-ground material, the problem of elevating and conveying became a serious one, not so much by reason of the quantity but rather by reason of the "floury" nature of the material. Those who have had experience with modern cement will appreciate the difficulty in handling it, and they know only too well the difficulties involved. This finely-ground material when conveyed with a spiral conveyor or elevated with a bucket-type elevator becomes intensely aerated, it "splashes" and "flows" like a liquid, and in this condition weighs nearer 60 lbs. per cubic foot than the more usual 90 lbs.

Realising and appreciating these difficulties, a "pump" has been evolved for elevating and transporting a product of this nature, and at the present time this type of pump is being used for pulverised fuel, finely-ground raw material, flue dust from kilns, as well as for finished cement. Although this method of transport has its limitations, it can with confidence be applied to most problems, and is the only economic solution to some. It is possible to transport material by this method through almost any tortuous passage; the transport pipe-line can be adapted to any reasonable and many unreasonable site conditions, and experience to date indicates that horizontal transport of something like 1,000 ft. in length is really practicable; no reasonable limit in height appears to have been reached, and cement silos up to 120 ft. high are being filled by this method with the greatest ease. Transport in a vertical pipe appears to involve less difficulty and less risk than transport in a horizontal pipe. If for any reason the air quantity or air velocity in a horizontal pipe falls, the material being transported tends to "drift"; this condition never occurs in a vertical pipe.



FULLER-KINYON PUMP — DIAGRAMMATIC ARRANGEMENT.

FIG: 1.

Referring to *Fig.* 1, the "Fuller" pump consists essentially of a hopper (*A*), spiral conveyor (*B*) with driving motor, closed cylinder (*C*), and air ring (*D*), interposed between the discharge end of the pump and the transport line. An air compressor is also necessary for producing the pressure air. The closed hopper or spout (*A*) is fed with the material to be pumped, at a reasonably uniform rate, by means of either an elevator or spiral conveyor. It is necessary for a sufficient quantity of material to be retained in the hopper to prevent the compressed air blowing

back. A grid is also necessary at (*E*) to prevent foreign matter entering the pump spiral.

The spiral conveyor (*B*) is of heavy design, the pitch is very open at the feed end but gradually diminishes towards the discharge end. It operates at a high rate of speed; the actual speed is 750 to 1,500 r.p.m., depending upon the size and duty of the pump. The usual method of driving is by direct coupling to an electric motor.

The spiral blading has a very small clearance in the cylinder (*C*). The air ring (*D*) with flange interposed between the flanged end of the pump barrel and the flanged end of the pipe line is of special construction. An annular chamber for the pressure air is arranged between the outer mating surface of the air ring bush and the inner surface of its flange. The air ring bush is drilled slightly in the direction of flow with a large number of small holes. The pressure air from the air pipe passes through the flange into the annular space and through the holes into the transport pipe, where it is intimately mixed with the cement being discharged. Pumping is thus effected by "conveying" at the beginning of the process and by the pressure air "carrying" at the latter part of the process. It

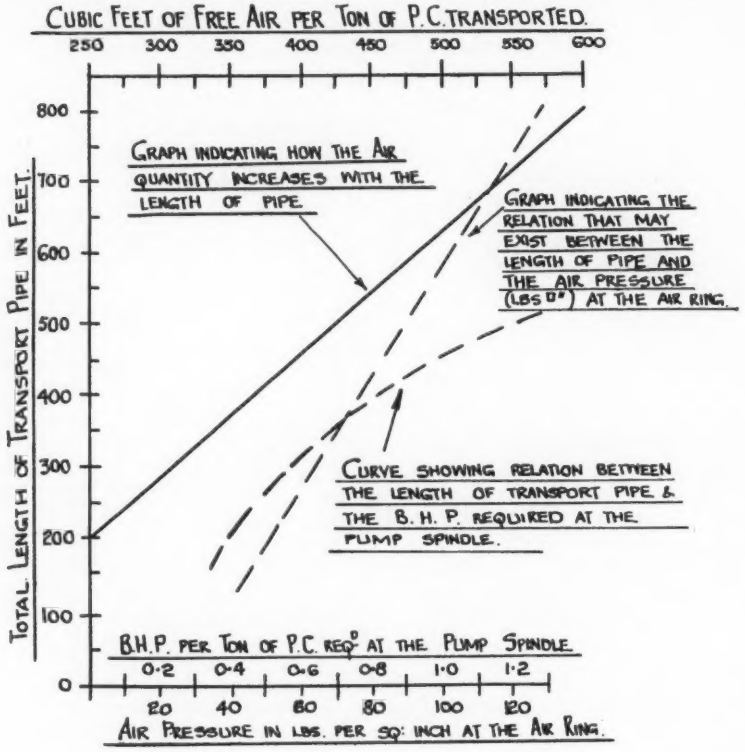


FIG: 2.

will be obvious from the construction of the pump that a considerable thrust will be exerted on the pump spindle, and a ball thrust bearing is fitted at the end of the spindle to take care of this.

The inherent moisture in the atmosphere when compressed becomes troublesome in the air ring when pumping cement; it is necessary therefore to filter or drain the moisture from the air when in the compressed condition, and this is best effected by means of a peat or coke filter and a frequent opening of the drain cocks. This filter usually takes the form of an air receiver, with the filtering medium in the middle section, tilted slightly so as to effect better drainage.

The figures given in the following table indicate generally the size, speed, capacity and power necessary for operating these pumps when dealing with cement. A

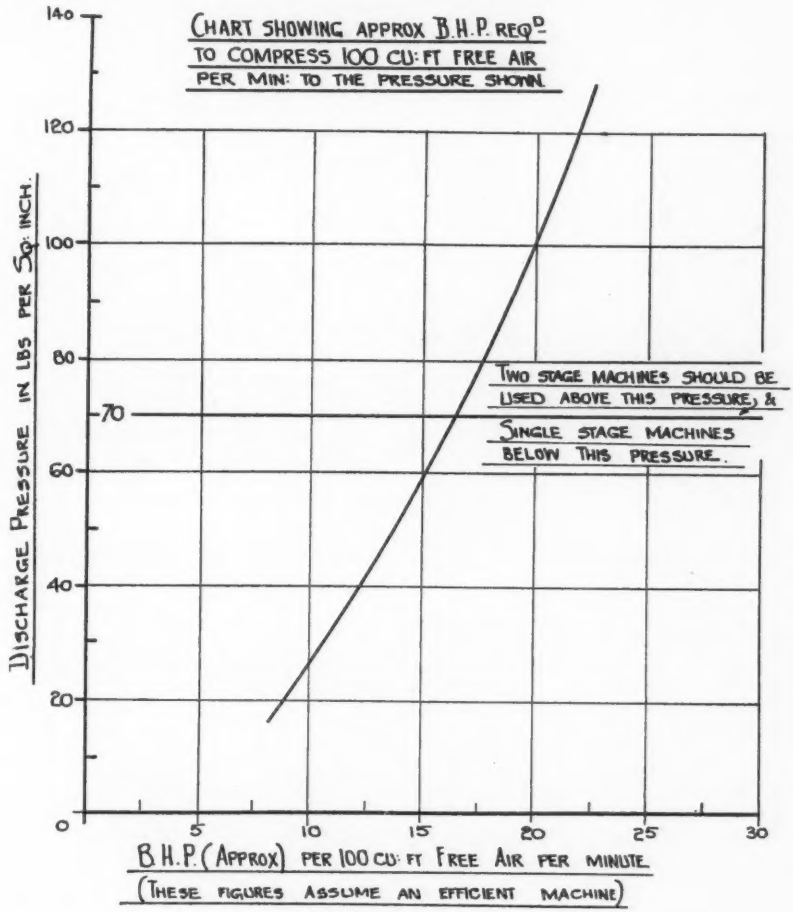


FIG: 3.

suitable size of pipe line for the range of capacities is also given.

Diameter of Spiral . .	4 in.	6 in.	8 in.	10 in.
Revs. per min.	1000–1500	750–1000	750–1000	750
Dia. of pipe line . . .	2"–3"	3"–5"	5"–6"	6"–8"
Tons of P.C/hr.	6–15	20–40	50–120	100–200
Pump House Power . .	12–30	30–60	80–150	120–200

An examination of the figures indicates a considerable range in each case; where the transporting distance is short, say, 150 or 200 ft., the lower power figure would be applicable; if the distance is, say, 500 or 600 ft., the larger power figure would be applicable.

The curves given in *Fig.* 2 are also illustrative of the above; they show graphically the connection between length of transport pipe and air quantity, air pressure, and B.H.P. at the pump spindle; the figures are only typical, however, and much would depend upon the length of horizontal and vertical pipes, the number of bends, etc.

In addition to the power required for operating the pump spindle, power for compressing the air represents an important item. Experience indicates that from 250 or 300 to 600 cu. ft. of free air per ton of material transported will be necessary, the smaller quantity for a comparatively short length of transport pipe and the larger quantity for a comparatively long length of transport pipe. A length of 150 to 200 ft. would be considered short and 600 to 800 ft. a long length.

The air pressure necessary for operation is also influenced by the length of the transport pipe. A length of 150 to 200 ft. will require a pressure of only 40 to 45 lbs. per sq. in., while a length of 500 to 600 ft. would require a pressure of say 100 lbs. per sq. in. (see also *Fig.* 2). A considerable range in this data is possible; for instance, the pressure can be cut down if the quantity is increased; the quantity can also be reduced if the pressure is increased.

The power necessary for compressing the air is indicated in *Fig.* 3, a reasonably efficient compressor being assumed. The figures given show the actual B.H.P. required at the compressor pulley or coupling for 100 cubic feet of free air compressed to the pressure given.

When the installation is correctly laid out, operated at its designed duty, and the pipe line is short, the power figure will be, say, 1 B.H.P. per ton for the pump and about the same for the compressed air. If the pipe line is long the figure would probably be as high as 2 B.H.P. per ton each for the pump and the compressed air. If for any reason the plant is operated at an output lower than that for which it was designed, the power per ton will be high. It is characteristic of this system, as of also most other conveying systems, that the total operating power at ***reduced*** tonnage will nearly reach that necessary for operation at the designed tonnage; that is to say, very little reduction in power will be effected if the plant be operated at 50 per cent. or even 25 per cent. of its designed capacity.

With intelligent operation the repair cost of units of this kind should be small, the principal items being the re-tipping of the wearing edges of the pump spiral, the replacement of the barrel liners, and repairs to any bends that exist in the pipe line. If the radius of the bends is large the amount of "scrubbing" on the inner surface will be small. If, however, the radius is small, the amount of scrubbing and the resistance to the flow of the cement-air mixture will be large. The radius of all bends should be as large as the installation will allow.

Special arrangements must be made at the discharge end of the pipe to effect an easy release of the air and to prevent quantities of dust escaping with it. When the material is being discharged into silos, a connection between adjacent silos should be provided. Each silo in the line or group can then act as a settling chamber, the air being finally released through a trunk or chimney with a cowled top, the velocity of release being not greater than 4 ft. per second. When the material is passed into an open warehouse it is necessary to discharge into a form of closed tank. Provision must then be made for extracting the material from this tank by means of a spiral conveyor. The air in this case would be released from the top of the tank through a filtration fabric, or something equivalent.

The system provides a useful means for transport to considerable height, or over considerable distances, or through an inconvenient or tortuous route. The running cost of the system, if intelligently installed and operated, should certainly be no more, and may be even less, than the cost of elevators and conveyors.

A 40,000-Ton a Year Plant.

THE Chinnor Cement and Lime Company, whose works are situated at Chinnor, eight miles north-west of High Wycombe (where they were established in 1908), have just erected a new rotary kiln plant capable of producing 40,000 tons per annum on a site adjoining the older plant.

The works are situated at the base of the northern slopes of the Chiltern Hills, and comprise 180 acres of land, composed of soft grey chalk which varies in calcium carbonate content between 50 per cent. and 90 per cent., thus supplying all the needs of cement manufacture without the necessity of importing any other raw material except gypsum for slowing the set.

The quarry is immediately alongside the factory, the chalk from it being won with the aid of a steam shovel. The raw material is washed in a 20-ft. washmill, and from there is passed through three further classifying machines

General View.

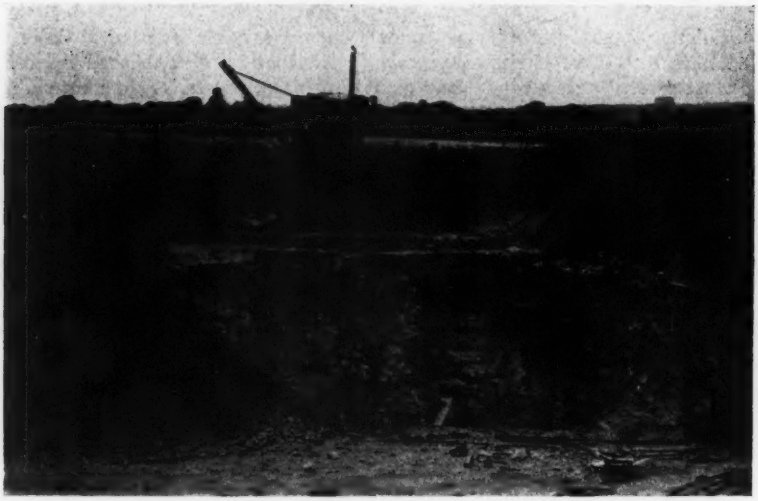
whereby the slurry is not allowed to pass to the pumps with more than a 5 per cent. residue on a sieve containing 32,400 meshes to the square inch.

The stored slurry is contained in three 600-ton vertical steel tanks, one of which is always supplying the kiln with slurry of the desired composition. The slurry in all three tanks is agitated by compressed air. The kiln slurry-feed is driven by the kiln so as to regulate the supply to the speed of the kiln. The kiln (by Messrs. Edgar Allen & Co., Ltd.) is 185 ft. long including a 20-ft. cooler on the discharge end of the kiln. A shaker conveyor by Messrs. F. L. Smidth & Co., Ltd., carries the clinker to the elevators and so to the mills.

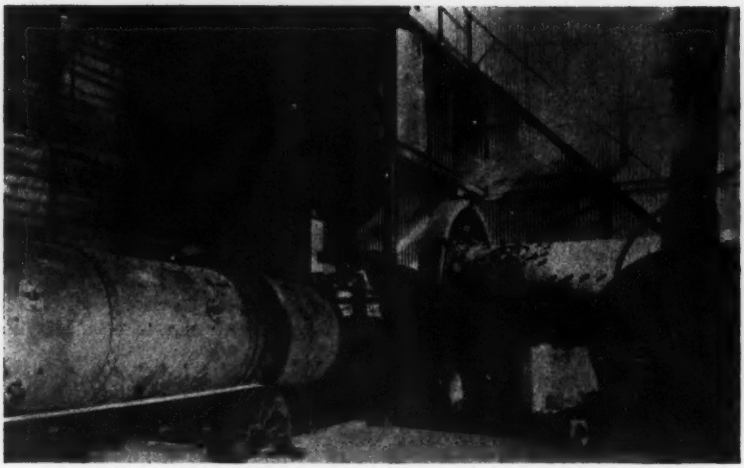
The cement mill is divided into four compartments, and is capable of grinding 7 tons per hour to a residue of rather less than 5 per cent. on a 180 sieve, or finer when making rapid-hardening Portland cement.

The coal is dried in a rotary drier and ground in the standard type of combination mill. The older method of coal preparation was deliberately chosen to ensure an evenly dried and ground fuel to the kiln.

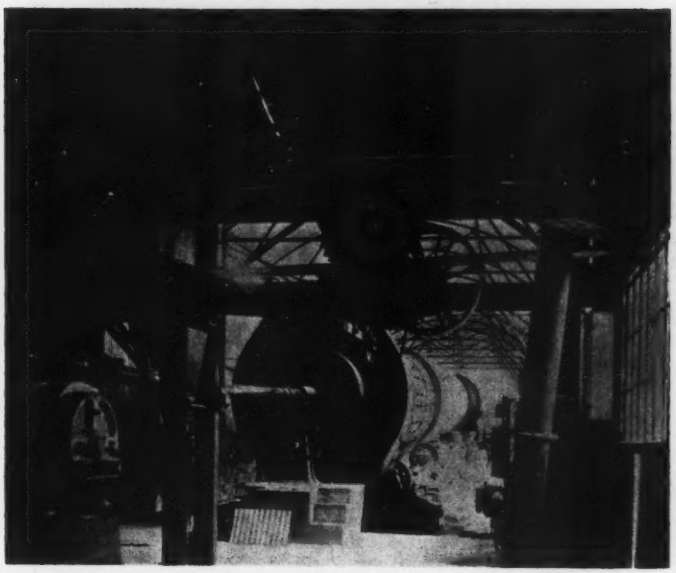
The cement is stored in silos of a capacity of 5,000 tons. There is a packing-house capable of storing 200 tons of cement packed in sacks, two siding connections with the G.W. Railway Co., and an ample lorry park.



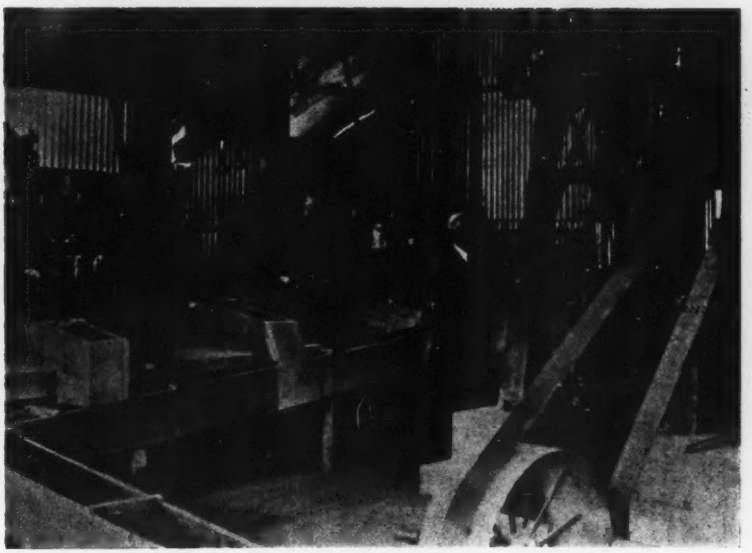
View in Quarry.



Grinding Mill.



Rotary Kiln.



Part of Wet Mill.

All the auxiliary machinery for a second kiln is now installed, and it is anticipated this will be completed by next midsummer.

Practically the whole of the cement-making machinery and buildings were supplied by Messrs. Edgar Allen & Co., Ltd., of Sheffield. All the electrical plant is by the Lancashire Dynamo & Motor Co., Ltd., of Manchester. Electricity is supplied from Aylesbury to the works substation by two separate overhead lines at 11,000 volts, and is transformed at the Company's substation for power and lighting purposes.

The Manager, Mr. A. A. Short, M.I.Mech.E., is responsible for the lay-out of the plant, and has supervised the erection of the works throughout.

Notes from Abroad.

Plant Extension in United States.

The plant of the Republic Portland Cement Company is now under construction at San Antonio, Texas. This plant will have a capacity of 3,000 barrels per day, and will manufacture cement from an argillaceous chalk by the wet process. Machinery employed is furnished largely by the Allis-Chalmers Manufacturing Company of Chicago, and Richard K. Meade & Company of Baltimore, Md., are the engineers.

South Africa.

There is an agitation for a protective duty against imported Belgian cement.

New Company in South Africa.

We understand the Eastern Province Cement Co., Ltd., of Hankey, Port Elizabeth, is to commence production at the end of this year.

New Works in Czecho-Slovakia.

We understand that a new cement factory is being erected near Trencin, with an initial capital of £24,545.

Increased Production in Australia.

The Adelaide Cement Company proposes to instal a new 60,000 tons unit. The present capacity is 48,000 tons per annum.

New Works in Brazil.

Consent has been granted for the erection of a new cement factory at Carandahy (Minas Geraes), Brazil. The Company is a Brazilian-Swiss promotion, with a capital of £288,000.

New Companies in Germany.

The Portland-Zementwerk "Alfen" G.m.b.H. is reported to be considering erecting works at Alfen, near Paderborn.

Portland Zement-und-Kalkwerk Salzderheldn-Vogelbeck A.G. is a new company which has been promoted by interests in Bremen, Bremenhaven and Berlin. The capital is R.M. 1,200,000 (£58,795). The location of the works is not yet divulged.

Zementwerks "Hellbach," Feldman & Co. is another company which will probably erect works in the Westphalian area, as it seems to be interested in the reparation deliveries to France.

CEMENT AND CEMENT MANUFACTURE
(Incorporated with "Concrete and Constructional Engineering")

The Maintenance of Cement Plant.

Divided Responsibility.

[By ALFRED B. SEARLE.]

THERE is something so massive and suggestive of strength about a cement plant that creates a feeling that it will last for ever. That bearings require relining, boiler-tubes need scaling, engines re-packing, kilns relining, and that various other repairs are necessary is not denied, but these are often regarded as trifles. The thought that the plant as a whole is gradually weakening seldom enters anyone's mind until some large repair becomes necessary and, in some instances, the whole of the works has to be stopped until the plant can again be put in good running order. Sales and production easily receive the attention which is their due, but maintenance, on which they ultimately depend, is too often neglected.

This matter became so serious in one works five years ago that it was realised that drastic measures were required. Parts of prime importance were breaking down so often that production was hindered and the cost of manufacture increased. The whole of the plant was examined in the fullest detail, a lengthy list of repairs and renewals prepared, and a series of recommendations handed to the directors. The causes of the repeated breakdowns were shown, the remedies indicated, and a definite policy whereby the proper maintenance of the plant could be secured was adopted.

The "Maintenance Manager."

The chief feature of this policy was to divide the works management into two parts: one manager to be responsible for production and the other for the maintenance of the plant in good running order. This novel arrangement seemed startling and possibly unwise at first, but four years' experience has shown the wisdom of it. The bogey of "divided authority" which worried some of the directors at first has never risen; it was avoided by making the powers of the two managers quite definite and distinct and by encouraging them to work together as much as possible.

After all the maintenance of the plant in good working order is just as important as the production of cement. This is easily seen by taking an extreme case and supposing that, as is done in some other industries, the labour required was let by contract to a man who would supply and control it for a definite price per ton of cement produced. Such a man's sole interest would be in production; he would probably provide no labour for keeping the plant clean, he would hesitate to do repairs until they were absolutely necessary, and he would tend to reduce the number of men employed whenever possible. Lacking the larger view which might be expected of a managing director, a contractor for labour would most likely "run the plant to death," and in a very few years the plant would scarcely be worth the proverbial "old song." The opposite extreme, which is never met in real life, would be a manager who kept the plant standing whilst brass name-plates were polished, or the windows of the kiln house were being cleaned.

Between these extremes is the ordinary cement works manager, who is equally responsible for production and for the maintenance of the plant. This dual position is an almost impossible one for most managers, because the interests

are at times conflicting. If production is the sole aim it is never likely to be convenient to close part of the plant, and the production manager, if left free, would wish to run on until so serious a breakdown had occurred that further production was impossible. Even then he would probably only "patch up" and go on, regardless of the fact that each "patch" was only shortening the time before the next breakdown would occur.

If, on the contrary, the maintenance of the plant were under a separate manager, he could work out a definite scheme, adapted to unforeseen circumstances, and relieve the production manager of a very serious mental conflict as well as enabling a larger output to be produced.

The maintenance manager is, above all, an engineer who understands plant; he sees where parts are beginning to warp or wear; he notes hot bearings or warm patches on the kiln; he observes or is told which parts of the plant are not running well, and does what is necessary to put them in order. If a machine has to be stopped for repairs, he decides—in co-operation with the production manager, yet not merely acting on the instructions of the latter—when the repair must be done, and if production is low because the plant is not in good order the maintenance manager must accept responsibility.

Adequate maintenance in a cement works requires a thorough knowledge of several branches of mechanical engineering, a considerable acquaintance with refractory materials and combustion, great ability to look ahead and co-ordinate the various sections of the plant, as well as to arrange what is to be done if various eventualities and contingencies occur. A maintenance manager must know the minimum quantity of spare parts which must be kept in hand, and what stores of timber, iron, nails, screws, bolts and other constructional materials are necessary. He must be able to decide, and to decide correctly, what is hindering production and how to put it right whilst making the most of the existing appliances. If any part of the machinery break down frequently he must be capable of designing a stronger part or of taking such other steps as may be needed.

The maintenance manager should have sufficient knowledge of materials to be able to buy wisely and enough freedom to be able to take advantage of "bargains" when they occur. He must maintain a very close inspection over every detail in the plant, for apparently small matters will put grinding and sieving plant out of action or render them inefficient.

He must have an instinctive horror of dirt—defined as "matter in the wrong place"—for this is the chief source of waste and breakdowns. He must "sense" when a machine is going to cause trouble and act before the breakdown occurs; he must be sufficiently ingenious to get the plant at work again immediately, even if it means working several nights in succession a little later when the rush of orders is not so great.

The proper maintenance of a cement works calls for many gifts on the part of the man responsible for it; a really capable maintenance manager is worth all he receives and more, for without his aid the real assets of the firm will so rapidly deteriorate in value that any profits which may be paid will be largely illusory.

Some owners of cement works have recognised the prime importance of maintenance; others, who have a vague idea that "something is wrong," will probably find a solution to some of their problems if they pay more attention

to maintenance; still others can be assured that unless their plant is adequately maintained the time when it will be shut down is not far off.

These may seem strong words, but no one has better opportunities for realising the penalties attaching to inadequate maintenance than the consultant who visits a number of cement works fairly regularly.

Book Review.

"Cements, Limes and Plasters." By E. C. Eckel.

Third Edition. Pp. xxxiv + 699. London: Chapman & Hall, Ltd. Price 35s.

THIS is a new edition of a book by an American writer dealing with American practice in the materials described. One of its merits is its comprehensiveness, because it is concerned not only with Portland cement but with lime, gypsum, plaster cement, magnesite cement, and aluminous cement. From a perusal of the book it is possible to obtain a general survey, comprising cost of production, methods of manufacture, and properties of all the cementing materials used in constructional work, and the relative advantages of the various cements can be compared. The value of the work is, however, seriously depreciated by the very superficial revision that has been made of the previous editions published in 1905 and 1922. It is unreasonable for references to events of 1904 and 1905 to be described in a 1928 edition as "recent," and the inclusion of a *forecast* of prices for the year 1926 tends to excite ridicule.

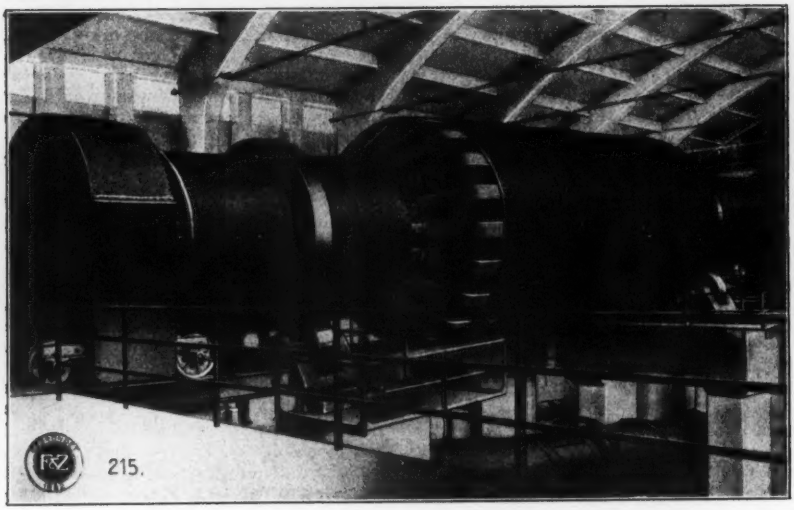
The reader naturally expects to find some information upon the more recent technical advances that have taken place in the processes of manufacture, but although some 300 pages are devoted to Portland cement there are no references to waste-heat boilers, de-watering of slurry, compound tubemills, unit coal pulverisers for firing kilns, pneumatic conveyors, mechanical grates for shaft kilns, dust precipitation, or many of the other recent developments that are the subjects of discussion when cement manufacturers meet. Instead of these there are discussions of the output of a 60-ft. rotary kiln, and such statements as "for very large installations steam and shafting are still the most economical and satisfactory"; and again, "we might further assume that the average H.P. hour will take 5 lbs. of coal." If the American cement producer will act upon such advice as this his European competitors in the international market have little to fear!

The author himself is apparently intensely national, because in a comparison *dated 1899*, which he states to be "quite representative," American cement is shown to give nearly 600 lbs. neat test at 7 days while English cement attains the same strength only after three months! The unfairness of this statement will be realised when it is remembered that the British Standard Specification for Portland cement—to which 100 per cent. of English cement is sold—requires a minimum of 600 lbs. neat test at 7 days. Another instance of unfair comparison is the inclusion of the 1904 edition of the British Standard Specification without any mention that this specification was obsolete in 1907.

In a quite proper argument for using cement in proportions relative to its quality the author states that engineers "insist, for example, in obtaining cement which will pass 92 or 95 per cent. through a 100-mesh sieve, and then use it in the same sand mixtures that they would if it were an English cement passing perhaps 85 per cent. through 100-mesh." This is, of course, a misrepresentation of the quality of English cements.

A portion of the book that is entirely new is a section on rapid-hardening cements, both Portland and aluminous. This is probably a more complete account of this subject in the English language than has yet been available, although it seems to show a scanty knowledge of the manufacturing methods of these new cements.

Certain other parts of the book are commendable, notably the chapters on raw materials and their excavation, but the inclusion of much misleading advice, such as that clinker or cement must be seasoned to slake free lime and that semi-bituminous coal must be ruled out for firing rotary kilns, makes it impossible for recommendation to the uninitiated reader.



Dry Process Kiln at Königshof.

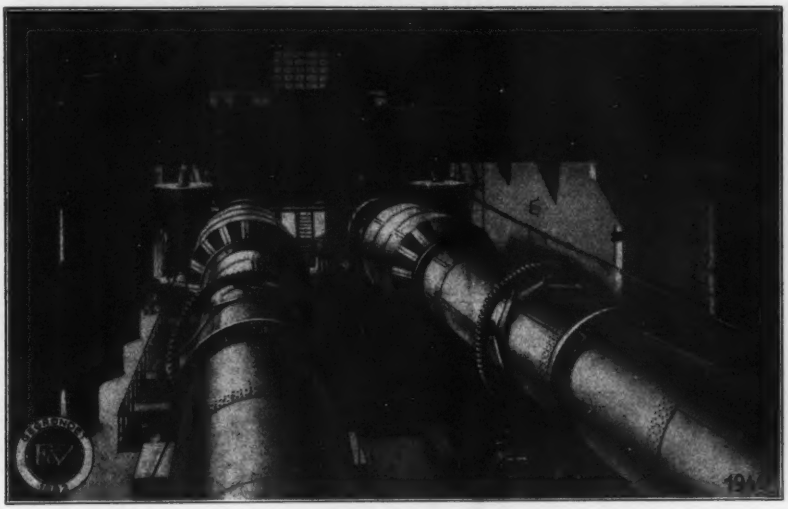
Enlarged Calcination Zones in Rotary Kilns. (*See* p. 101.)

Enlarged Calcination Zones in Rotary Kilns.

By GEOFFREY MARTIN, D.Sc., Ph.D., F.I.C., F.C.S.

FOR several years past the specially-constructed type of rotary kiln described in the following article has been in successful operation on the Continent, but none appears to have been erected in this country. The rotary kilns referred to are fitted with enlarged decarbonating zones—which must not be confused with the enlarged sintering zone, of ordinary Kilns.

The zone built into the kiln under discussion is of a very much greater diameter than that of the normal cement kiln, and in this enlarged zone the material is not "sintered" but only "decarbonated," i.e., heated to the correct temperature to expel the carbon dioxide from the mass, but not to a temperature

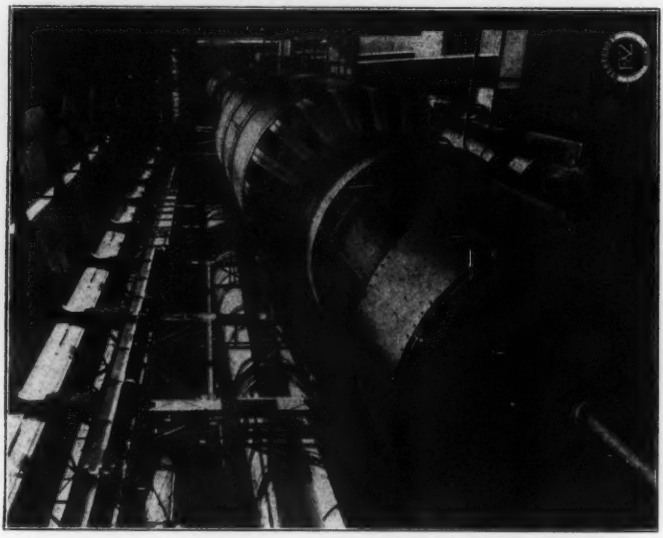


A Dry Process Kiln.

high enough to cause the formation of cement clinker. It is a well-known fact that the raw material in a kiln—especially in the dry process—shows a tendency to "rush" forward in an irregular manner, with the consequence that the output of the kiln is seriously reduced and the resulting clinker shows irregularity of quality. It is obvious that the raw material traversing a kiln in the ordinary way can never be uniformly treated so that every particle is in exactly the right condition to enter the sintering zone and be at once converted into cement clinker. This is due to the fact that in the dry process the material tends to traverse the kiln in a series of "rushes," so that material often reaches the sintering zone before it is properly decarbonated, whilst in the wet process there are not only small particles, but also medium-sized particles and even quite large masses of raw material from slurry rings and clinker rings, impinging into the sintering zone. The larger particles travel through the kiln at speeds different from those

of the smaller particles, with the result that the particles arrive in the sintering zone unequally calcined.

All these deficiencies are claimed to be overcome by the enlarged calcining zone built into the kiln just before the sintering zone. The raw material collects in considerable quantities in this zone, and its progress through the kiln is arrested for an additional two hours. The consequence of this is that the material is uniformly and thoroughly calcined, ready and properly prepared to go into the sintering zone. It is therefore easy to see that by introducing such well-calcined materials into the sintering zone much larger quantities can be sintered in a given time, and as a result the coal consumption will be much reduced. The following gives some recent data on this point :—



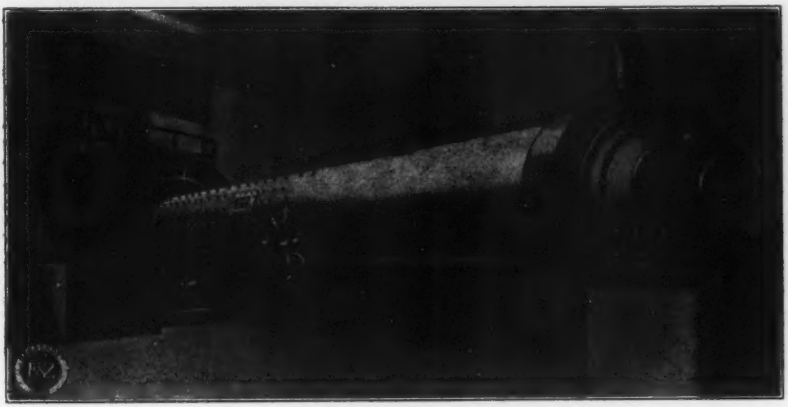
Wet Process Kiln.

DRY PROCESS.—Two kilns were erected at the Königshofer cement factory in Königshof. Their sizes were 3 metres (9 ft. 10 ins.) diameter by 50 metres (164 ft.) long. Each was fitted with an enlarged calcining zone 5 metres (16 ft. 5 in.) diameter by 9 metres (29 ft. 6 in.) long. Both kilns operated on the dry process under forced draught. The exit gases escaped at a temperature of 650–700 deg. C. (1,200–1,300 deg. F.) and were passed through a waste-heat boiler. These waste gases developed 4,000–4,400 KW. (5,000–5,900 HP.), i.e. more power was produced than sufficed to run the whole works, and part of this power was delivered to another works. The output of clinker was 280–300 tons per twenty-four hours, in spite of the fact that the raw material was very high in calcium carbonate (78 per cent.) The coal consumed varied between 1,350 and 1,400 calories per 1 kg. clinker (19 to 20 tons of standard coal per 100 tons of clinker).

WET PROCESS.—One kiln of 3 metres (9 ft. 10 in.) diameter and 50 metres (164 ft.) long, fitted with a calcining zone 5 metres (16 ft. 5 in.) diameter by 9 metres (29 ft. 6 in.), gave an output of 270–280 tons in twenty-four hours, with a coal consumption of 1,600 to 1,700 calories per kilogram of clinker (23 to 24 tons of standard coal per 100 tons of clinker). It should be mentioned that the raw materials treated in this kiln were admittedly the most difficult materials in Germany to burn.

In another place, where better raw materials were at hand, the kiln yielded 300 tons and more with a coal consumption of about 1,600 calories per kilogram clinker (23 tons of standard coal per 100 tons of clinker).

Several ordinary rotary kilns of the same dimensions, viz. 3 metres diameter (9 ft. 10 in.) by 50 metres (164 ft.), which were working side by side with the above-mentioned two kilns fitted with the enlarged calcining zones and using exactly the same raw materials, had an output of 210 tons per twenty-four hours



Three-Chamber Mill.

with a consumption of 33 to 34 tons of standard coal per 100 tons of clinker, the coal having a calorific value of 7,000 calories (12,600 B.Th.U.'s per lb.), that is, about 2,300 to 2,400 calories per kilogram of clinker. It will be seen from this difference in fuel consumption and output that the enlarged calcining zone was here very successful.

Other kilns now operating give similar outputs and coal consumptions. It has been proved that on the average the introduction of these enlarged calcining zones leads to an increase of output of about 30 per cent. and a diminution of coal consumption of about 25 to 30 per cent. Moreover, it is claimed that in the kilns fitted with the enlarged calcining zone a far better burnt clinker is obtained than has hitherto been possible, while crushing and tensile strengths are increased by 20 to 30 per cent. due to the fact that the raw material, which must pass through the decarbonating zone, is held up in this zone for two hours longer than usual and thereby comes into the sintering zone far more completely decarbonated than is the case with the ordinary rotary kiln.

GRINDING.—As regards grinding, there is now on the market a new three-chamber mill which works without any sieve and without inset gratings. The first chamber contains special plates of a special construction, and the second chamber is lined with ordinary smooth armour plates. Between the second and third chamber is placed a patented partition which enables it to be set within the space of ten minutes at most for any desired degree of fineness, whereby the advantage ensues that the single chambers can be kept steadily filled with the requisite amount of material so that the rate of wearing away of the grinding plates and chambers always remains normal. The plates are made of chrome steel produced in an electric furnace. By means of a patented setting-device it is possible to set the mill at its highest degree of grinding efficiency for every kind of material to be ground.

The mill runs suspended on plummer blocks, the latter being lubricated by rings running in circular grooves filled with oil. The drive is by two methods —one by means of a direct drive from a motor, by employing reducing gear in the form of cogged wheels and toothed gearing, the other by a central drive attached between the motor and the mill shaft in the form of a flexible reduction gear. The wheels in this method of drive are all flexibly arranged in a suitable reduction gear-box.

The plants above referred to were manufactured and erected by the firm Fellner & Ziegler Akt, Frankfort-on-Main.

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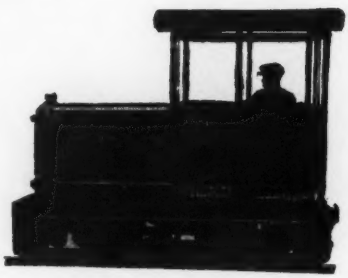

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The Portland Cement Industry To-day.

By A. C. DAVIS, M.I.Mech.E., M.Inst.C.E.I., F.C.S.

As the classifications of hydraulic cements vary, so do the definitions of Portland cement, and the opinions on what shall be included in the term. To be perfectly clear as to what Portland cement is officially considered to be to-day, the descriptions of Portland cement in the largest cement-consuming countries are given as follows :—

Great Britain.—An intimate mixture of calcareous and argillaceous or other silica and alumina bearing materials burnt at a clinkering temperature and ground to a fine powder. No addition of any material, other than calcium sulphate or water, or both, shall be made after burning. No cement to which slag has been added or which is a mixture of Portland cement and slag will comply with this specification.

U.S.A.—The product obtained by finely pulverising clinker produced by calcining to incipient fusion an intimate and properly-proportioned mixture of argillaceous and calcareous materials with no additions subsequent to calcination except water and calcined or uncalcined gypsum.

Germany.—An hydraulic cementing material with not less than 1·7 parts by weight of lime to 1 part by weight of soluble silica (SiO_2) + alumina (Al_2O_3) + oxide of iron (Fe_2O_3), prepared by fine grinding and intimate mixing of the raw materials, then burning at least to sintering, and fine grinding. To the Portland cement shall not be added more than 3 per cent. of other materials for special purposes.

France.—Portland cement shall be produced by grinding an intimate mixture of carbonate of lime, silica, alumina, and iron burnt to the point of incipient fusion.

Belgium.—Artificial Portland cements are obtained from artificial mixtures of carbonate of lime and clay or from any other materials comprising lime, silica, and alumina. These mixtures strictly proportioned, finely ground, and perfectly mixed are subjected to burning to the point of incipient fusion. Grinding of the scorified rock (or clinker) thus obtained gives a fine powder which constitutes artificial Portland cement. After burning, artificial Portland cements may not be mixed with any material without losing their name. Exception is made for an addition of gypsum in quantity strictly necessary for regulation of the setting.

The foregoing descriptions are taken from the standard specifications for Portland cement for the countries named, and the evolution of these specifications provides interesting evidence of the progress in the material to which they relate.

In Great Britain a Standard Specification for Portland Cement was first issued by the Engineering Standards Committee in December, 1904. So rapid have been the changes and improvements in the manufacture, however, that it had to be revised in less than three years (June, 1907), and other revisions followed in August, 1910, March, 1915, August, 1920, and October, 1925.

In 1904 it was considered sufficient to require that a mixture of 1 part of cement to 3 parts by weight of dry standard sand should bear a tensile stress of 120 lbs. per sq. inch at 7 days. In June, 1907, this minimum figure was increased

to 150 lbs.; in March, 1915, to 200 lbs.; and in October, 1925, to 325 lbs. That is to say, in less than 21 years the standard requirement for strength of cement mortar had been raised from 120 to 325 lbs. When it is remembered that these figures represent minimum requirements, and that it is necessary for manufacturers to be at all times able to manufacture cement which gives a substantial margin over them to allow for the human element of error in testing, the progress made will be appreciated. This actual progress on the manufacturing side is well illustrated in *Fig.* 1, showing the development in the quality of Portland cement since 1862.

The greatest advance in the industry has been during the past few years in the introduction of rapid-hardening Portland cement, a super-quality Portland cement first produced in Great Britain. Rapid-hardening Portland cement is a superfine Portland cement, costing a little more than ordinary Portland cement but considerably cheaper than aluminous cement. Since the days when lime, the forerunner of Portland cement, was recognised as requiring months to attain a reasonable degree of hardness, there has been a steady development both in the final strength of the binding material and in the rate at which this strength is attained, until we come to the present-day rapid-hardening Portland cement, which, unlike aluminous cement, is a true Portland cement made with the same raw materials as Portland cement of a more refined manufacture.

The process of manufacture is similar to that of Portland cement in that it demands the same materials, conditions, and machinery, but it differs in respect of chemical composition and degree of burning and grinding. The CaO content is increased, and this entails careful manipulation of the proportioning and mixing of the raw materials. This increase of lime content is liable to render the cement unsound unless the burning is effected with the utmost precision and is sustained for a longer time than in the case of ordinary Portland cement. The extra burning renders the resultant clinker harder than usual, and this demands more careful manipulation, more power, more plant, and more wear and tear in the process of grinding.

Clinker, as it falls from the kiln, has no cementitious properties until it is ground into an impalpable flour, and as the setting and hardening of cement depend entirely upon the area of the surface of the particles produced it is obvious that the ideal is obtained when the residue remaining on a 180-mesh sieve is the least attainable. In the case of rapid-hardening cement produced in Great Britain to-day the residue is as low as 1 to 2 per cent. on the 180-mesh sieve (having 32,400 holes to the square inch).

The advantages of rapid-hardening Portland cement are numerous. The saving of time, and consequently of money, by its use varies in almost every form of concrete work, but in most cases it is substantial. It takes considerably less time to harden than ordinary cement, and the value of a rapid-hardening cement is particularly noticeable during the winter when the hardening of concrete is retarded by low temperatures. Concrete during setting and the early stages of hardening is liable to attack and partial destruction by severe frost, but when a rapid-hardening cement is used this risk is considerably decreased, because the period required to reach the necessary degree of resistance to the attack of frost is less than with ordinary cement.

Economy in shuttering and moulds is effected. The length of time during

which the shuttering or moulds must remain in position depends entirely upon the rate of hardening of the concrete, and where this time is reduced by the use of rapid-hardening cement the shuttering or moulds can be more quickly removed, thus rendering less the amount required.

When used in connection with repairs to roads the period of time inconveniencing the progress of traffic is considerably reduced.

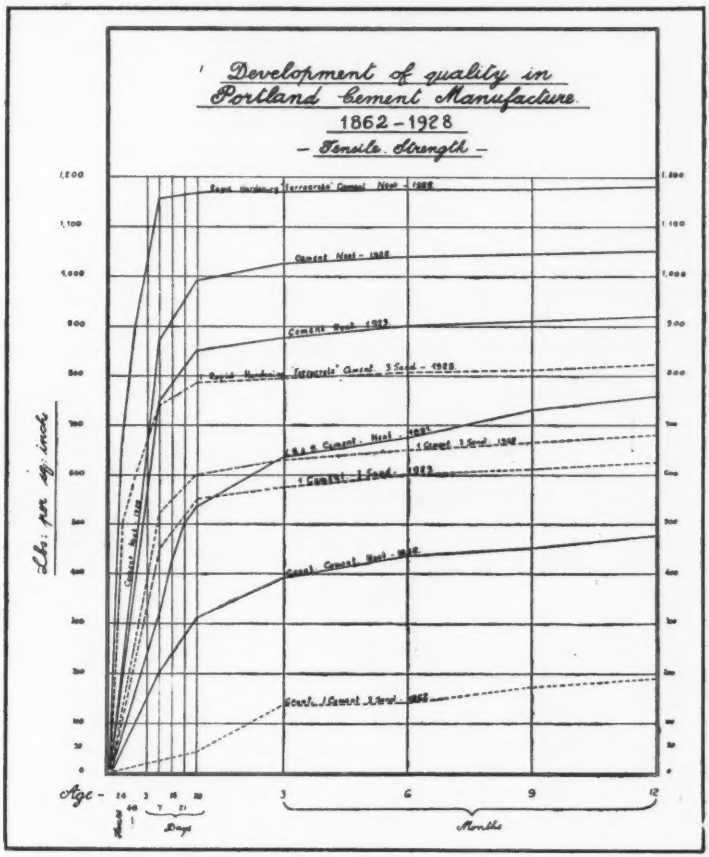

Fig. 1.

A feature of rapid-hardening Portland cement and aluminous cement is that it is not quick initial setting, and therefore allows ample time for mixing and placing the concrete in position before the set commences.

The comparative tests of rapid-hardening and ordinary Portland cements will be more easily realised by a glance at *Fig.* 1.

The introduction of national standard specifications for cement in the various countries of the world, referred to earlier, has naturally and of necessity been accompanied by standardisation of the methods adopted for making the various tests prescribed. It is very much to be doubted, however, whether methods of testing cement can be said to have kept pace with the progress in the improvement of the quality of the article itself.

There is between the various national specifications some general agreement as to the qualities required in cement, and in respect to which it is to be submitted to test. These qualities, broadly, are the chemical composition; the time taken to set; the strength to be attained in a given time; and the important quality of constancy of volume or soundness. It is common practice also to prescribe the fineness to which the cement is to be ground, but, as fineness of grind is only a means towards attaining the other qualities desired in a cement, there is some divergence of opinion as to the need to specify it.

Wide divergence comes in when it is necessary to decide how such qualities shall be determined. For example, it is easy to prescribe that the cement when mixed with water shall not "set" or harden within a certain time, but it is necessary also to decide how and by what means the test shall be made. Here the difficulties inherent in standardising cement testing at once begin to manifest themselves. All cements are affected in their characteristics by the amount of water used with them, and by the temperature and other conditions obtaining during testing.

It is therefore necessary, as a first step, to prescribe the quantity of mixing water to be used, and there is yet no prescribed method by which two testers in different places and without consultation will exactly agree as to the proper quantity of water to be used for mixing a given sample of cement. Vicat introduced the method of applying the end of a weighted rod to the surface of cement paste and determining its consistency by the time and depth of penetration, and this procedure is used to-day in some specifications. It is, however, very approximate, and in fact can only be used with reasonable success if the cement is mixed with a quantity of water far in excess of that which it really needs; the results are also influenced by the amount of mixing the tester has given the paste. In Great Britain an attempt has been made to arrive at a common agreement on the basis of a paste which is plastic when filled into the moulds used in the tests. Although this has been fairly successful in practice among expert testers, it is admittedly lacking in precision and a more precise method is still being sought.

With this initial difficulty in the way of accurate cement testing still to be satisfactorily solved, it is perhaps not surprising that the whole technique of the subject is lacking in precision and scientific application. There is room, and indeed urgent necessity, for an improvement in the methods of testing cement which will place it on a more scientific and exact basis.

While fifty years ago the manufacture of Portland cement was quite an empirical trade, at the present time it ranks among the greatest chemical industries of the world, carried on, as it must essentially be, by trained chemists and mechanical and electrical engineers. The increase in size of the industry in Great Britain, its growth in precision, are comparatively small, however, in ratio with its development over the world as an industry of the utmost importance.

To-day in the United Kingdom the manufacturing capacity is rapidly

growing toward 7,000,000 tons per annum. The consumption at home is less than this tonnage by at least a million tons a year, and three-quarters of this excess manufacture is exported.

The increasing competition of Continental cement is causing some perturbation in many parts of the world. Cement imports into Great Britain during the years 1925, 1926, and 1927 were approximately 219,000, 333,000 and 420,000 tons respectively. Belgium is by far the principal source of imports, followed by France and Denmark. Continental cement does not command the price of the British product, and is used mainly on work where it is thought a cheaper cement can be satisfactorily employed. It is to be remembered that Belgium, from both a natural and an economic standpoint, is fortunately placed for the manufacture and exportation of Portland cement. During 1913 Belgium produced approximately 1,465,000 tons and exported about 866,000 tons, or 59 per cent. of the total production; Belgian production in 1927 is estimated at 2,633,000 tons, about 91 per cent. of its indicated capacity, and the exports amounted to 1,600,000 tons, or 60 per cent. of the production. This high ratio of export to production is achieved with a wages scale and other charges very much below those obtaining in this country.

While the technical progress in the cement industry has been substantial in the past few years this has not been confined solely to the chemical or mechanical side, but improvements have, in Great Britain at any rate, definitely taken account of the human factor. Working conditions, wages, and measures for the welfare, safety, and recreation of cement workers have advanced very rapidly in recent years, and the position to-day compares very favourably with that of workers in most other heavy industries.

During the past decade many new factories have sprung up throughout the United Kingdom, old factories have been demolished and rebuilt, and others again have been thoroughly remodelled and modernised, with the result that smaller factories with their increasing burden of high production costs are closing down, and many factories are so unfortunately affected to-day.

The centres of the manufacture of Portland cement in Great Britain are well distributed, namely, in the north and south, the Midlands, the east of England, and Wales in the west. In Ireland works are situated at Larne and Wexford; in Scotland, near Glasgow and Edinburgh. Altogether there are to-day about 65 factories in England, 4 in Wales, 4 in Scotland, and 2 in Ireland, owned by about forty different manufacturers or companies.

The normal size of a modern cement factory is one having an output of at least 1,200 tons of Portland cement per week, and in the United Kingdom alone there are individual cement factories producing 7,500 and 10,000 tons of cement per week each.

The capital cost of all the factories in the United Kingdom, based upon a broad estimate including the usual accessories of the business, would approach some £25,000,000, and the number of workers directly engaged in the industry approximates 12,500.

Up to the end of the last century the cement industry still remained a heavy and laborious one, in which most of the operations were carried out by man power, working sometimes under very uncomfortable conditions, for example, in loading and discharging the "chamber" and other types of kilns used. Not

only was this work heavy, but men had to work in temperatures which made the wearing of the scantiest of clothing almost unendurable. This has now passed. It is true that some progress had then been made in the mechanisation of the mixing of the raw materials, and the substitution of ball and tube mills for the earlier millstones used for grinding the clinker had improved efficiency and labour conditions in those departments. Nevertheless conditions were such that it was mainly only lowly-paid agricultural labour which was willing to enter the cement factories of those days, hence the low labour rates which long applied.

Dating only from the early years of the present century an almost complete revolution has been effected in cement works operation, and all heavy operations are to-day more efficiently conducted by machines. The digging of the raw materials, formerly carried out by small armies of men with great personal exertion and at considerable risk, is now done by mechanical excavators. The chamber and other kilns are replaced by the rotary kiln, in which the mixed raw materials and fuel are automatically and continuously fed, and the whole drying and clinkering operation carried through under the control of one man. The dusty and heavy work of shovelling the ground cement into casks and sacks by hand and wheeling the packages on hand trucks to the loading platform is replaced by automatic filling and weighing machines and conveyors.

In the early days, when manufacture was confined mainly to the rivers Thames and Medway, this country was then supplying the world with cement; but with the increasing use of Portland cement it was soon discovered that with proper knowledge and skill the material could be made from a variety of geological deposits containing as their chief constituent carbonate of lime, which is widely distributed in the earth's crust. Thus, after a time, the great cement-producing centres in England found their trade abroad contested by a growing local manufacture, and in consequence the exports of cement from the United Kingdom into many foreign markets were only able to be continued at such prices as to be barely remunerative. Shortly after its initial manufacture in England, France quickly followed in her own production of Portland cement; Germany, too, very soon developed her own cement manufacture. At the same time our largest single customer, the United States, developed its own manufacture with such rapidity and on so huge a scale that European manufacturers quickly found themselves deprived of an outlet for a great quantity of their products. To-day, however, the American cement manufacturers, like the British, are concerned about the increasing use of Belgian cement in their domestic markets due to the economic factors previously referred to, but have not been able to do much to curb this trade because of price differential.

The alteration in trading conditions due to the development of Portland cement manufacture in other countries led to an urgent necessity to effect economies and improvements in the quality in cement manufactured at home, and this gradual improvement of quality has always made British cement superior in quality in the markets of the world.

In one hundred years since Aspdin's time the world's total output of cement has reached at least 95,000,000 tons annually, and it is reasonable to assume that with the enormous progress to-day in the uses of Portland cement the present decade will see at least 100,000,000 tons of Portland cement consumed each

year. Separated into Continents the production of Portland cement to-day is as follows :—

America	44,260,000	tons
Europe	41,780,000	,,
Asia	6,690,000	,,
Australia	1,950,000	,,
Africa	990,000	,,
Total	95,670,000	tons

It is of interest here to examine the figures of annual production of cement per head of the population in some of the chief cement producing countries. These figures are :—

United Kingdom	$2\frac{1}{2}$	cwts.
Belgium	7	,,
United States of America	$6\frac{1}{4}$	,,
Denmark	$3\frac{1}{2}$	,,
Norway	$2\frac{3}{4}$	,,
Germany	$2\frac{1}{2}$	,,

It has been mentioned earlier that some 60 per cent. of the Belgian production is exported from that country, but in the case of the United States by far the greater proportion is consumed within its own territories. The United States may therefore claim to have the highest consumption of cement per capita—as is indeed to be expected in a vast country not fully developed but with a large and enterprising population.

Trade Notices.

Coal Distillation.—Messrs. Babcock & Wilcox, Ltd., have issued a brochure of considerable interest dealing with the " Babcock " low-temperature coal distillation system as applied to electric generating stations. The Company is prepared to design and manufacture low-temperature carbonisation and by-product recovery plants, in conjunction with complete steam raising equipments to meet any specified conditions, and invite inquiries from engineers and others interested in problems of this description.

Quarry Plant.—Messrs. Edgar Allen & Co., Ltd., have sent us a copy of " The Edgar Allen Mine and Quarry Book," which gives in summarised form an account of the products the firm supplies for the use of mines and quarries. The subjects discussed range from crushing and grinding machinery (including stone-breakers, ball mills, tube mills, etc.) to lime hydrators ; rotary dryers ; replace parts for crushing machinery in manganese steel, chrome steel, and other steels, hollow and solid mining drill steels ; steels for granite working ; etc. This book should be of considerable value to all mining engineers and quarry managers, and a copy will be sent on application to Edgar Allen & Co., Ltd., Imperial Steel Works, Sheffield.

Recent Improvements in Portland Cement.

In a paper read before the Institution of Structural Engineers on November 22, Mr. D. B. Butler, A.M.Inst.C.E., F.C.S., dealt with the recent improvements in the strength and constructive value of Portland Cement. In the course of his remarks he said:

It is, perhaps, scarcely realised what enormous improvements have taken place recently in the quality of Portland cement, all over the world, altogether apart from the introduction and evolution during the past four or five years, of rapid-hardening Portland cement.

A series of seven days neat and sand tensile tests of twenty-five consecutive samples of ordinary Portland cement, received in 1928, suggested that the strength tests of the British Standard Specification might again be stiffened with advantage, assuming that the object of the Specification is to reflect the average strength of the commodity. In further support of this view, it may be mentioned that one of the leading reinforced concrete specialists in this country has for some time past specified that ordinary Portland cement for all his work shall develop a minimum 7 and 28 days 3-1 sand cement mortar tensile test under the British Standard Specification conditions of testing, of 400 lbs. and 500 lbs. per square inch respectively, and judging from the author's experience no difficulty whatever has been experienced in obtaining material of this strength.

As regards fineness of grinding, also, it would appear that the current British Standard Specification requirements might be considerably stiffened without inflicting hardship; British cement is now very rarely met with which gives as high a residue as 10 per cent. on the 180 sieve, which is the maximum of the current British Standard Specification, although some of the Continental products occasionally reach or exceed that figure. Tests on the fineness of twenty-five consecutive samples of British and foreign origin recently passing through our laboratory confirm the suggestion that the British Standard Specification requirements in this respect might be reduced to 7·5 per cent., or even lower, and would still leave a very considerable margin according to present day practice.

On the subject of the British Standard Specification, the author would suggest the desirability of omitting altogether the 28-day test, and substituting one of an early date, say, 3 days. It is largely the practice, at all events in this country, to accept or reject cement on the 7-day tests, without waiting for the 28-day results, which, as a general rule, are confirmatory only; from the users' point of view, therefore, it would be of much more value to have a 3-day test than one at 28 days. For many years before the introduction of the British Standard Specification it was the custom in the author's laboratory, and also in that of his predecessor, the late Henry Faija, to make 3-day tests in addition to 7 and 28 days, and in the majority of instances it is possible to forecast with a fair amount of accuracy the probable strength at 7 days from that developed at 3 days. In fact at the present time the author frequently makes use of a 3-day test as the basis of a preliminary report in cases of emergency, and the earliest possible release of a consignment is essential. The determination of the fineness, setting time, and soundness, together with 3-day tensile tests and chemical analysis, is, in nine cases out of ten, quite sufficient to enable a fairly accurate opinion to be formed as to whether a sample of cement could be used without appreciable risk. Based on average modern products the author would suggest that a 3-day tensile test of 500 lbs. neat and 300 lbs. sand would be fair and reasonable, and one that no modern manufacturer would have any difficulty whatever in meeting.

In further support of the suggested 3-day test it may be mentioned that instances have occurred in which a cement develops a satisfactory strength at 7 days, but is so slow in the initial stages of hardening that it would cause considerable loss and delay in any constructive work in which it might be employed. A striking example of such a cement came to the author's notice some four years ago. Complaint was made to the suppliers that concrete made from a certain consignment failed to harden satisfactorily even after 14 days in position, and a sample was submitted for examination. Tested and analysed

in accordance with the British Standard Specification then current, it complied with the requirements thereof in every respect, as shown by the following figures :—

Fineness.—Residue on a No. 180 × 180 sieve : 6·2 per cent. Residue on a No. 76 × 76 sieve : 0·1 per cent.

Setting Time.—Initial : 4¾ hours. Final : 8 hours.

Soundness by the Chatelier test. After 24 hours aeration the sample developed 1½ millimetres expansion.

Tensile Strength.—7 days : 563 lbs. neat and 276 lbs. sand. 28 days : 766 lbs. neat and 434 lbs. sand.

Chemical Analysis.—

Water and carbonic anhydride	2·15
Insoluble residue	·11
Silica	24·26
Alumina	5·94
Oxide of iron	3·50
Lime	60·03
Magnesia	2·48
Sulphuric anhydride	·51
Alkalies and loss	1·02
	100·00
Hydraulic modulus	2·31

Suspecting from the behaviour of the briquettes and pats 24 hours after moulding that the cement was scarcely normal as regards hardening properties, an additional set of briquettes was made for testing at 3 days, which gave an average of only 292 lbs. neat and 75 lbs. sand. This showed the cement to be abnormally slow as regards its initial hardening properties, and, although it complied in every respect with the British Standard Specification requirements then in force, it can be readily understood that it would cause considerable trouble in use and fully justify the complaint in question. The adoption of a 3-day test as suggested would have at once detected this weakness and justified the rejection of the consignment, with which, according to the British Standard Specification regulations then in force, no fault could be found.

Perhaps the greatest improvement, if it may be so called, in modern cement manufacture during the past four or five years is the evolution of rapid-hardening Portland cement, a material which bids fair to revolutionise all hitherto generally accepted ideas as regards rapidity of concrete construction.

One of the leading firms of British manufacturers of Portland cement, realising the effect the introduction of aluminous cement would have upon their industry, set to work to produce a material that would enable them to compete with this product upon more equal terms, and after considerable experiment and research rapid-hardening Portland cement was the result. Since the cost of rapid-hardening Portland cement is only about 7s. 6d. per ton greater than that of ordinary Portland cement it will be readily understood that it is rapidly becoming a highly important branch of the Portland cement industry. Owing to its obvious advantages in the saving of time in concrete construction work generally, it is quite possible that a few years hence it will become the more important branch of the two.

The only specification for rapid-hardening Portland cement in this country of which the author is aware is that of a leading reinforced concrete consultant; this specification deals only with the strength of the 3-1 sand-cement mortar at one, three, and seven days, the minima at these dates being 300, 500 and 600 lbs. per square inch respectively. The better qualities of rapid-hardening cement would have no difficulty in complying with these requirements, and in the author's opinion these figures might well form the basis of a British Standard Specification, at all events for the present.

It has been found, however, that with the 24-hour test especially a very great deal depends upon the details of manipulation in preparing the briquettes and their subsequent treatment, some of which details apparently do not affect to any marked extent the test pieces used for the 7-day or even the 3-day tests. In the first place, there is the percentage of water used for gauging, a very slight variation in which will make considerable difference in the results obtained; this, however, applies to all cement tests, since it is well known that the smaller the percentage of water used, provided there is sufficient to flux the material into a compact solid mass, the greater the strength developed.

Another point that appears to make an immense difference with the 24-hour

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test, but does not appear to affect tests at a longer period to the same degree, is the temperature and humidity of the air in which the test pieces are stored while maturing. Here again it is well known that a low temperature retards and a high temperature accelerates the hardening of Portland cement; the limits as regards temperature of the present British Standard Specification for ordinary Portland cement are 58 degs. to 64 degs. Fahr., but it would appear that with the 24-hour test of rapid-hardening Portland cement these limits are too wide, and that it makes a very considerable difference whether the temperature during maturing is maintained at the highest or the lowest limit; in the author's laboratory the approximate mean is adopted of 62 degs. Fahr.

There is yet another point which will require careful consideration, and that is the amount of trowelling and gauging a cement shall receive in making the setting time and other tests. The only clause in the current British Standard Specification dealing in any way with this point is Clause 10, which stipulates that "the cement shall be mixed with such proportion of water that the mixture shall be plastic when filled into the moulds for forming the briquettes." It has been found, however, that the time occupied in gauging and trowelling sometimes exerts a very considerable influence upon the results of the setting time tests.

In conclusion, the author would like to emphasise the fact that with present-day Portland cement, the engineer has at his disposal an infinitely stronger and better material than he had a few years ago: a result that is due partly to improved machinery but more particularly to better all-round control of the manufacturing process, in which the works chemist plays an increasingly important rôle. Looking back only to the first issue of the British Standard Specification in 1904, it is little exaggeration to say that the average strength and cementitious value of present-day Portland cement is nearly double what it was then; and this without taking into consideration the recently introduced rapid-hardening Portland cement, a material which, judging from the progress made since it was first put on the market some three or four years ago, promises to become of increasing importance in the near future.

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